CITY SMOKE AND HEAT EFFECTS ON MINIMUM TEMPERATURES[1]

By FRED L. DISTERDICK

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One of the most persistent problems that a Weather Bureau official is required to solve is to give a satisfactory explanation of the discrepancy existing between the usual minimum temperatures reported from Weather Bureau stations and those reported by reliable instruments exposed in the same locality but under natural conditions, or under conditions that are as near natural as it is possible to find. This question is by no means a new one and it came up as often 25 years ago as it does at the present time. The answer usually given is city influence, which may be one or a combination of several causes, the principal one of which is smoke and artificial heat, accompanied by very little wind. That the artificial conditions existing in all cities have a marked influence on the temperature of the air is a fact recognized by every one, but few realize how great the discrepancy may be under favorable conditions. Most discussions of this subject treat of the average conditions and the exceptional cases are not brought to light. Should the smoke evil be remedied to any great extent it is believed that the city influence as affecting the daily minima would be very much lessened.

Several years ago it was observed at Des Moines that there was a pronounced tendency for the minima to be lower on Sunday and Monday mornings than the conditions would ordinarily warrant and it became the established practice at this station to place the expected minima on these days lower than the other days of the week. In attempting to assign a cause for the assumed conditions, it was suggested that nearly all office buildings bank their fires on Saturday afternoon, that the large number of switch engines in the immediate vicinity are idle from Saturday noon till Monday morning and that all factories near by are closed down for a like period. As a consequence, compared to the rest of the week, there is very little smoke from Saturday afternoon till Monday morning in the vicinity where the official Weather Bureau thermometers are exposed, and radiation during this period is very little hindered.

In order to verify this assumption actual conditions were investigated for a period of 20 years during the months in which minimum temperatures were forecast. It developed that the minima for Sunday and Monday averaged below the minima for the several months considerably more than half the number of times, and the mean for these two days was less than any combination of two days or single days. This condition would be a natural sequence of the lessened smoke and less artificial heat, and radiation would be possible on Sunday and also on Monday before new fires are kindled.

In dealing with exceptional cases it had been the general policy, when great discrepancies were brought to notice, to be skeptical of the reports or condemn the instruments with which the comparisons were made. A casual study of climatological data does not reveal the exceptional cases which are constantly occurring. The mean temperature of Weather Bureau stations and cooperative stations does not differ materially, but in a State where the general contour is such as Iowa, the regular Weather Bureau stations always show higher mean values and considerably higher mean minima. This situation is recognized by the Iowa Weather and Crop Bureau in its study of the relation that temperature bears to the development of crops and in all the growing season it is necessary to reduce the values represented by the regular Weather Bureau stations at times more than one degree, to harmonize with open exposures where the influence of artificial conditions is negligible. Also in determining the length of the growing season, it has been found necessary to exclude the data from the regular Weather Bureau stations and a number of the larger cooperative stations because the city influence as affecting plant growth is not given proper consideration. This situation is apparent by the examination of a frost table showing the length of a growing season.

Where it is possible to have daily contact where there is no city influence, the discrepancies, as revealed by instruments, are easily verified by the observation of natural phenomena. Many times during the last 10 years it has been possible both to note the instrumental discrepancies and also to observe the contrasts as revealed by the different effects in near-by places. During the last five years it has been possible to make observations under the most favorable comparative conditions. Every spring and fall it is a common occurrence to observe the ground in the open country frozen at times to a depth of more than 1 inch and ice on small pools has been observed more than one-half inch thick, while the minimum temperature at the Weather Bureau station would show several degrees above the freezing point.

More than 25 years ago it was deemed advisable to add to the daily forecast, during the season when freezing temperatures were expected, a statement indicating the lowest temperature that was expected to be reached. If a figure close to the set figure was recorded it was considered a good forecast and the first thought was a good verification. As the value of these forecasts increased it became necessary to include a larger area and the probable temperature that would occur away from city influence had to be considered. During the spring and fall truck growers are more concerned as to how low the temperature will go in their gardens than what the lowest temperature at the city Weather Bureau office might be. This fact was strikingly demonstrated several years ago when a minimum temperature of 35° was recorded at the Weather Bureau office and some of the outlying portions of the city reported a light frost, where conditions favored. As is usual, inquiry was made and conflicting reports were received as to the amount of frost damage. Some reports were that there had been no damage and one report was that everything had been killed. This report was doubted and the party making the report was considered as a pessimist and had not complete verification been secured this occasion would have passed with no further comment. However, late in the afternoon in question, in crossing a ravine through which a small stream flowed, a small pool was discovered that was still completely covered with ice, thick enough to withstand the thrust of a moderate-sized stone. This condition did not seem possible and the incidents in connection have resulted in a policy at Des Moines to consider more what the temperature might reach in a locality where damage from a freeze would result than that which may be recorded at the location of a Weather Bureau station. From a close contact with many people that are subject to frost

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damage it is well established that it often happens that there is very little damage in areas in the path of a light wind carrying smoke and serious damage will result in other areas not so protected. The effect of a smoke protection can be easily observed every year if the trouble is taken to visit different areas in the same vicinity. Directly west of Des Moines is a large open area more than one-half mile wide. In this area the effects of frost are observed early and there is never any smoke to ward off an injury in a critical condition. Rather early during September, 1929, a frost occurred that killed practically everything in the unprotected area. In advancing eastward the extreme edge of the city showed only traces of frost and as the city was penetrated even the most tender vegetation was not injured in the least and continued to thrive for more than a month after areas immediately adjoining were entirely without vitality.

In order to obtain positive information, reliable instruments were exposed for a time several years ago, to see just how much temperature readings in the open country and the city exposure differed, the exposures being less than 5 miles apart. It was disclosed that when conditions were favorable for radiation in the country and the city was covered with a smoke blanket, the readings were never less than 5°, most of the time they were 10°, or more, and on one occasion a difference of 17° was noted, ranging from 35° at the country exposure to 52° at the Weather Bureau office. A great deal of the climatological data that is being compiled is, at best faulty, and it would seem that the time has come when the question of securing more accurate climatological data should receive some serious thought. The principle of smoke and artificial heating is made use of on a large scale as a protection against frost at many places, particularly in the far Western States, when the crops are in danger. It is known with a great deal of certainty just how much heat may be produced in a given case and it would seem as logical to consider the artificial conditions produced in these orchards in determining their climatology as accepting the data from smoke-infested cities as being the climatological record of them. No absolute solution seems possible but it is thought that stations at, or near, air ports would offer the best solution. The situation complained of in the larger cities is gradually being felt more and more at a large number of cooperative stations. There are, however, a few cooperative stations with which comparison can be made with Weather Bureau stations that are troubled by smoke. The cooperative stations are as near natural as is possible to find anywhere. Each cooperative station is compared with the nearest regular Weather Bureau station. The average absolute minima for each month was taken and the city influence on the minima is apparent at once.

Table showing extreme minima at Weather Bureau stations and selected cooperative stations, period 1925–1928, inclusive

	January	February	March	April	May	June	July	August	September	October	November	December
Decorah	−17	−8	2	15	30	37	44	43	30	14	8	−16
Dubuque	−11	1	8	21	38	46	52	51	37	24	14	−8
Average monthly difference in extreme minima, 7.7°.												
Davenport	−9	7	9	24	37	47	52	52	38	24	14	−6
Sigourney	11	5	8	22	35	45	50	50	34	20	11	7
Average monthly difference in extreme minima, 2.2°.												
Des Moines	−7	1	11	28	37	48	55	52	37	23	12	−6
Winterset	−13	−1	6	20	28	41	47	45	32	17	8	−9
Average monthly difference in extreme minima, 5.8°.												
Omaha	−7	4	13	27	40	51	57	54	39	26	14	−4
Glenwood	−9	3	10	24	34	46	51	46	34	20	9	−5
Average monthly difference in extreme minima, 4.2°.												

Average minima and monthly means at Davenport and Davenport No. 2 for the period 1924–1928, inclusive

EXTREME MINIMA

	January	February	March	April	May	June	July	August	September	October	November	December
Davenport	−11	7	10	25	39	48	53	54	39	27	12	−7
Davenport No. 2	−13	5	8	23	34	45	48	49	35	23	9	−11
Average monthly difference, 3.4°.												

AVERAGE MONTHLY MEANS

Davenport [1]	22.9	31.0	37.7	50.1	60.4	68.4	74.6	73.2	65.4	53.9	39.2	24.5
Davenport No. 2 [2]	23.0	31.2	38.2	50.8	60.9	68.3	74.6	73.2	65.8	53.6	39.5	24.3

[1] Annual, 50.1. [2] Annual, 50.3.

THUNDERSTORM TOP KNOTS

By CHAS. F. BROOKS

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A perfectly formed cumulo-nimbus cloud housing a small but energetic thunderstorm passed within hearing distance south of Greenwich, Conn., the evening of July 11, 1930. At the time of its best development, 7:15–7:25 p. m., eastern standard time the heavy vertical mass of the thunderstorm was probably 10 km.[1] wide from east to west. The outspreading top sheet of heavy mammato-alto-stratus extended about 3 km. on either side. The convective air, most active in the front and in the rear portions of the south-eastward advancing storm and the outspreading top, was more or less a double affair spreading from these two sections. The vertical thickness of the top sheet was of the order of 1½ km., and the height of the top at least 6 km.

[1] All dimensions are based on rough angular measurements made from an elevation of about 100 m. and 4 km. from Long Island Sound, at Greenwich, Conn.

Above the western trunk of active convection a cumulus knob would appear rather rapidly, grow upward to a height of ½–1km. above the level of the top, then fall back, the complete process taking from 3 to 5 minutes. While the top knot was growing lightning was visible in it every 3 to 15 seconds, but when it was falling back lightning was less frequent, and was of the order of one-half minute to a minute. Lightning in the trunk below the top knot was still more frequent.

As a particularly large knob at 8 p. m., eastern standard time, fell back into the mass of the top sheet, great mammato-cumulus forms appeared on the under surface of the top sheet. These mammato forms were about as large as the top knob itself had been, and were evidently from the air which had come from the upper protuberance and which was now falling back and spreading out. So